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APPLICATION

Of

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For

UNITED STATES LETTERS PATENT

On

SHIP HULL CLEANING APPARATUS AND METHOD OF USE

Sheets of Drawings: two (2)

TITLE: Ship Hull Cleaning Apparatus and Method of Use

BACKGROUND OF THE INVENTION

RELATED APPLICATIONS:

This application is a follow-on application to U.S. Provisional application Ser. No. 60/232,027 filed 09/12/2001, and entitled "Improved Ships Hull Cleaning System." The contents of the aforementioned application are incorporated by reference herein.

INCORPORATION BY REFERENCE:

Applicant(s) hereby incorporate herein by reference, any and all U. S. patents, U.S. patent applications, and other documents and printed matter cited or referred to in this application.

FIELD OF THE INVENTION:

This invention relates generally to cleaning devices, and more particularly to ship hull cleaning devices.

DESCRIPTION OF RELATED ART:

The following art defines the present state of this field:

Sierra et al., U.S. 3,946,692 describes a device for cleaning immersed surfaces comprising a supporting structure carrying rotary circular brushes for cleaning the surface and wheels for moving the device on the surface. When rotated the brushes produce a force of attraction towards the surface. Transmission means, for example, calibrated springs, transmit to the wheel a predetermined part of the force of attraction so that the force with which the brushes

are pressed against the surface is diminished and the adhesion of the wheels to the surface is ensured.

Maasberg et al., U.S. 3,984,944 describes a device for cleaning surfaces which extend in a vertical plane and particularly ship's sides, tank walls and similar surfaces which are made of ferromagnetic material, comprises a lifting mechanism which has roller means permitting it to run along a ship's railing or similar structure adjacent the top of the surface to be cleaned. The lifting mechanism includes one or more winding drums or hoists, which carry support line means which extend from the lifting mechanism to a carrier for a cleaning apparatus. The cleaning apparatus advantageously includes a housing having an undercarriage, which is movable along the surface to be cleaned and which includes magnetic means for causing an attraction between the carrier and the surface to be cleaned so that the carrier is held thereagainst during the cleaning operation. The cleaning apparatus advantageously comprises a cleaning spray beam which extends substantially horizontally and which has one or more spray nozzles along its length for the spraying outwardly of a cleaning agent, such as a liquid, or for applying a sand-blasting action or a cleaning substance against the surface to be cleaned. The support line means advantageously comprises at least a flexible conduit, which permits the support of the carrier as well as the transmission of a fluid to the spray, which is mounted on the carrier. The flexible conduit is advantageously connected to a high pressure pump for supplying the liquid or similar substance to the carrier at its location along the surface to be cleaned and the hoisting means is effective to move the carrier upwardly and downwardly as the lifting mechanism is advanced along the length of the surface.

Wickersham, U.S. 4,030,440 describes a boat cleaning apparatus comprising framework for suspending a boat in the air, a frame having rotatable brushes positioned to clean a portion of the length of the sides and bottom of the boat, spray nozzles attached to the frame for directing an aqueous acid solution or steam against the boat, and wheels supporting the frame and enabling the frame to be moved along the length of the boat. The brushes rotate as

the frame is moved along the length of the boat and thereby clean the full length of the sides and bottom of the boat.

Sabella, U.S. 4,060,047 describes a device for cleaning the bottom of a boat or the like while the boat is afloat in the water comprising a pair of rods pivotally connected at corresponding end, a cleaning member pivotally connected to the end of one rod and an adjustable clamp for setting a desired angular position between the rods. Stabilizing members assist in aligning the cleaning member with the surface of the boat.

Norris et al., U.S. 4,236,477 describes a device for progressively cleaning the hull of a boat being moved forwardly along a prescribed path. The device includes a submersed stationary support frame. A hull-cleaning framework is mounted to the support frame and is elevationally movable thereon between a partially submerged operative condition, and an above surface inoperative condition. A number of brush supporting arms are pivoted on the hull cleaner framework and extend along the path of a boat through the device at their outer ends. The arms are biased inwardly toward the path for yieldably urging the rotating brushes against the boat hull regardless of its configuration. The device will automatically adapt itself to a wide variety of powerboat and sailboat hull shapes. Vertical brushes are provided to clean the downwardly projecting keels of sailboats. Transverse bottom, intermediate and side brushes are independently pivoted to accommodate sailboat hulls or many other forms of boat hulls. The keel, bottom, intermediate and side brushes transversely overlap each other to clean adjoining longitudinal sections of a boat hull regardless of the hull shape.

Oram, U.S. 4,462,328 describes a cleaning device for removing foulant from the hull of a sea going vessel comprising a carriage, a plurality of cleaning nozzles secured to the carriage, a reactor nozzle aligned to produce a reactive force which opposed the force component of the cleaning nozzles which tends to urge the carriage away from the hull of a ship, and control members for displacing the carriage across the hull surface of the vessel. The control member can be flexible, in which case the reactor nozzle is also aligned to

tension the control members. In any case, the control members provide remote control of the carriage throughout a regular pattern of predetermined paths.

Burgers et al., U.S. 4,648,344 describes a device for scrubbing marine growth from the submerged portion of a boat hull; said device being particularly concerned with manual operation by one person from deck or dockside and comprising an operator's guidance handle attached to a flexible arm to which is fastened on its underside, surface-seeking-flotation and to its upper surface, scrubbing material which when moved about on the submerged portions of a boat's hull scrubs therefrom unwanted marine growth.

Feurt, U.S. 4,784,078 describes a floating small boat cleaning facility formed from a floating dock assembly having a pair of laterally spaced longitudinally extending side walls, a front entrance end wall, a rear exit end wall, a bottom wall, and a top wall spaced downwardly from the top edge of the side walls, to form a buoyancy chamber. The outside surface of the side walls have brackets to receive anchor pilings that have their bottom ends secured to the sea bottom. The front end wall and the rear end wall have a cutout portion formed adjacent their top edge and a plurality of vertically oriented strips of flexible material have their bottom ends attached to this top edge to form an entrance curtain and an exit curtain through which boats may pass. The curtains have structure for maintaining them in a floating substantially vertical orientation. As a boat passes through the entrance curtain, its presence is detected and signals are transmitted to the central control and computer room, which controls the drive wheels that carry the boat through the floating dock assembly. As the boat progresses through the floating dock assembly, its presence is further detected which causes the brush wheel assemblies to be actuated for cleaning the water surface area of the boat.

Nellessen, Jr., U.S. 4,841,894 describes a trolley to convey brushes for cleaning a stationary hull that is drawn along the bottom and sides of the hull. Brushes are supported by variable buoyancy chambers to make the biasing of the brushes against the hull also in turn variable. The trolley can be supported and stored in a dock or alternatively supported by a floating

platform. There is an electrical motor drive for a chain, which pulls the trolley. A diesel prime mover may be used in the floating platform to generate power for the electric motor chain drive and for the submersible motors.

Sterling, U.S. 4,991,533 describes a boat brush for cleaning the submerged portion of the hull. The brush has a high degree of structural strength, adequate clearance during operation as no part of the brush frame will make unwanted contact with the hull, and the brush contacts all of the hull with a two position locking brush head.

Rogers, U.S. 5,174,222 describes a device for in-water cleaning of a ship's hull. The device includes a body having inboard and outboard faces joined by a peripheral side, the faces having coaxial central apertures which are joined to form a central opening through the body, in which is mounted a hydraulic motor-driven propeller. The propeller maintains the device in contact with the hull during cleaning. There are detachable wheel modules recessed into the body to propel the device along the hull and a hydraulic motor-driven steering wheel to steer the device. Hydraulically driven cleaners are mounted on the inboard face to clean the hull. There is also a light recessed into the peripheral side to provide illumination to the hull. The device may also include an adjustable buoyancy chamber mounted on the body to provide sufficient buoyancy to the device to enable the device to effectively clean the hull at the waterline. Also disclosed is a unique double bearing for mounting each of the wheels, cleaning means and propeller which prevents hydraulic fluid leakage and permits easy demountable of the compounds.

Maloney et al., U.S. 5,222,452 describes an apparatus that includes a support mechanism for supporting the cleaning apparatus in the body of water, a hull cleaning assembly including a plurality of brush assemblies, and a mechanism for moving the brush assemblies between hull cleaning positions and hull clearing positions. The brush assemblies each have a buoyancy element, a motor supported by the buoyancy element, and a cleaning brush coupled to a drive shaft of the motor. The buoyancy elements of the brush assemblies are

hinged together to constitute a unified hull cleaning assembly. The moving mechanism includes a control device for controlling the movement of the brush assemblies. In addition, the moving mechanism includes a plurality of control lines movably engaging the support mechanism. The control lines are connected to the brush assemblies respectively at one end and to the control device at the other end. The support mechanism includes a pulley arrangement rotatably secured therein. The control lines movably engage the support mechanism through the pulley arrangement. Methods are also contemplated by the present invention. These methods comprise the steps of (1) supporting the cleaning apparatus in the body of water; (2) maneuvering the boat hull over the brush assemblies; (3) floating the brush assemblies to a cleaning position around a bottom portion of the boat hull by employing the buoyancy elements of the brush assemblies; and (4) actuating the cleaning brushes of the brush assemblies into a cleaning action by driving the motors of the brush assemblies.

Templet, Jr., U.S. 5,431,122 describes an apparatus for cleaning ship hulls underwater. A frame is supported by controlled buoyancy tanks, which may be flooded to sink the apparatus beneath a ship, blown to a neutral buoyancy for easy underwater maneuvering, or blown to a positive buoyancy so to adhere against the inverted hull of a ship. The apparatus, when underwater against a hull, rides on two independently powered wheels, which are individually driven by hydraulic motors for individual control by the diver. These wheels, extending above the upper surface of the apparatus in its submerged position, engage the hull, driving the apparatus along the hull. At the forward end of the apparatus is a reciprocating chipper blade, an angled or concave, hardened steel blade driven by a vibratory impact apparatus at a high repetition rate through a very short stroke. The distance of the stroke and the speed of the blade is such that the impact of the blade cleans the hull of the barnacles, but does not exert a rearward force which would overcome the traction of the wheels. The apparatus will clean the hull of marine growth, but does no damage to the hull or to the paint on the hull.

Weber, U.S. 6,067,921 describes a cleaning installation which consists of at least one cleaning roller which can be driven to rotate, is rotatably mounted in a rack and whose roller structures are positioned at least partially below the surface of the water.

Our prior art search with abstracts described above teaches a device for cleaning ship's hulls and other immersed surfaces, a device for cleaning ship's sides, tank walls, and similar surfaces, a boat cleaning machine, a device for cleaning the bottom of a boat, a boat hull cleaning device, a ship hull cleaning device, a floating small boat cleaning facility, a hull cleaner, a boat bottom cleaning device, an apparatus for cleaning of ship hulls, a boat hull cleaning apparatus, an apparatus for cleaning the submerged portion of ship hulls, and a device for external cleaning of ship's hulls, but does not teach a ship hull cleaning apparatus and method of use comprising an articulated arm that is dynamically adjustable and has a brush head assembly pivotably mounted on its free end for cleaning the underwater portion of a ship's hull. The present invention fulfills these needs and provides further related advantages as described in the following summary.

SUMMARY OF THE INVENTION

The present invention teaches certain benefits in construction and use which give rise to the objectives described below.

The present invention is an apparatus and method of use for cleaning the underwater portion of a ship hull and includes a support frame, at least one articulated arm installed on the support frame having a plurality of members interconnected by hinge connections, a hydraulic cylinder mounted between respective ones of the members so as to adjust each hinge connection and thus manipulate the arm, and a brush head assembly mounted at the free end of the articulated arm so as to be positionable by the articulated arm against the ship hull. The support frame is rotatably mounted on a base that is installed on a carrier such as a land mass, a pier, a dock, a land vehicle, or a boat, so as to allow for convenient positioning

of the apparatus adjacent to the ship to be cleaned. A laterally-extending stand-off arm is mounted on the support frame to safely locate the carrier adjacent to and spaced from the ship. The brush head assembly may include one, two, or three or more brush drums rotatably mounted within a yoke that is pivotably installed on the free end of the articulated arm. A monitoring device is mounted on or about the brush head assembly to monitor the location and movement of the assembly relative to the ship hull. A pressure nozzle is also mounted on or about the brush head assembly to cooperate with the brush drums in removing debris from the ship hull and in clearing the area for better monitoring by the monitoring device.

In use, the ship and the ship hull cleaning apparatus of the present invention are located adjacent to and spaced from one another. The articulated arm is then manipulated to position the brush head assembly underwater in the vicinity of the ship hull. The hydraulic cylinder system installed on the articulated arm cooperates with the monitoring device under the direction of a control device in the nature of a control loop so as to dynamically and automatedly position the articulated arm so that the brush head assembly is in contact with the underwater hull. The brush drums mounted within the brush head assembly are then rotated to clean the underwater hull. The pressure nozzle may also be activated to remove debris loosened by the brush drums.

A primary objective of the present invention is to provide an apparatus and method of use of such apparatus that provides advantages not taught by the prior art.

Another objective is to provide such an invention with an articulated arm capable of positioning a brush head assembly mounted on the free end of the arm in contact with the underwater portion of a ship's hull for cleaning.

A further objective is to provide such an invention capable of dynamic adjustment of the location and movement of the brush head assembly.

A still further objective is to provide such an invention capable of automated adjustment of the location and movement of the brush head assembly.

A further objective is to provide such an invention capable of installation on a number of carriers for convenient location of the invention adjacent to a ship to be cleaned.

A still further objective is to provide such an invention capable of safely locating the invention adjacent to and spaced from a ship to be cleaned.

A further objective is to provide such an invention capable of improved removal of debris from a ship hull.

Other features and advantages of the present invention will become apparent from the following more detailed description, taken in conjunction with the accompanying drawings, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate the present invention. In such drawings:

Figure 1 is a side elevational view of the preferred embodiment of the invention;

Figure 2 is an enlarged, partial side view thereof;

Figure 3 is an enlarged, partial side view of an alternative embodiment thereof; and

Figure 4 is an enlarged, partial perspective view of an alternative embodiment thereof.

DETAILED DESCRIPTION OF THE INVENTION

The above described drawing figures illustrate the invention in at least one of its preferred embodiments, which is further defined in detail in the following description.

The present invention is a ship hull cleaning apparatus **10** generally comprising a support frame **20**, at least one articulated arm **40** configured having a plurality of members **42** interconnected by hinge connections **44** and installed on the support frame **20** so as to have a free end **46**, hydraulic cylinders **48** mounted between respective members **42** of the articulated arm **40** for dynamically adjusting the hinge connections **44**, and a brush head assembly **60** mounted at the free end **46** of the articulated arm **40** so as to be positionable by the articulated arm **40** against the ship hull **102** for cleaning. As shown in Fig. 1, the support frame **20** is mounted on a base **22** that is itself installed on a carrier **90** such as a boat so that the cleaning apparatus **10** may be located adjacent to the ship **100** to be cleaned, as explained more fully below. While the carrier **90** is shown and described as a boat, it will be appreciated by those skilled in the art that the frame **20** and base **22** may be installed on a number of other carriers, including a land mass, a pier, a dock, or a land vehicle. With any such arrangement, as set forth in detail below, the cleaning apparatus **10** of the present invention serves the advantageous purpose of cleaning a ship hull **102** without having to take the ship **100** out of the water. Furthermore, where the frame **20** is installed on a boat, it will be appreciated that the cleaning apparatus **10** may be brought to the ship **100**, rather than bringing the ship **100** to the cleaning apparatus **10**, enabling the cleaning of a ship even anchored at sea or in a harbor far from a dock or pier. In a preferred embodiment, the frame **20** is enabled for rotation relative to the base **22** so as to more effectively position the brush head assembly **60** against the ship hull **102**. This rotation may be achieved through a track and roller engagement, ball bearings, slides, or any other such rotatable mechanical coupling device now known or later developed in the art. The articulated arm **40** is installed on the frame **20** so as to extend from one side of the frame **20** generally down and away from the

carrier **90** in a cantilevered fashion. It will be appreciated that such installation and the action of the articulated arm **40** in positioning the brush head assembly **60** against the ship hull **102** during use will cause an uneven weight distribution about the carrier **90**. To counterbalance this effect and prevent a carrier **90** such as a boat or land vehicle from capsizing or any other non-moving carrier from being subjected to extreme torsional or bending forces during operation of the articulated arm **40**, the frame is provided at its side substantially opposite of the articulated arm **40** with a counterweight **24**. The counterweight **24** is preferably shiftable along the support frame **20** so as to most effectively counterbalance or offset the articulated arm **40** during use. To further stabilize the carrier **90** and to protect the ship **100** during cleaning, the apparatus **10** is further formed with at least one stand-off arm **26** mounted on the support frame **20** so as to extend laterally thereof and space the apparatus **10** from the ship hull **102**. In the embodiment shown, the stand-off arm **26** is formed on its distal end with a roller **28** configured to make rolling contact with the ship hull **102**. The length of the stand-off arm **26** is preferably adjustable through pins, screws, turnbuckles, a hydraulic or pneumatic cylinder, an electric motor, or other such static or dynamic adjustment devices now known or later developed in the art so as to effectively space the articulated arm **40** from the ship hull **102** and be retracted and out of the way during non-use. As mentioned above, the action of the articulated arm **40** is achieved through the hinge connections **44** interconnecting the arm's respective members **42** and the manipulation of those hinge connections **44** through hydraulic cylinders **48** installed on adjacent members **42**. The linear movement of the cylinders **48** adjusts the angular position of one member **42** relative to another. As such adjustment takes place along the length of the articulated arm **40**, the position of the free end **46** of the arm **40**, and thus the position of the brush head assembly **60**, is modified. While a hydraulic cylinder is shown as the mechanical device operating between respective members **42** of the articulated arm **40** to pivot the hinge connections **44** and control the overall movement of the arm **40**, it will be appreciated by those skilled in the art that numerous other devices such as a hydraulic ram, a hydraulic motor, a pneumatic cylinder, a pneumatic ram, a pneumatic motor, or an electric motor may be employed without departing from the spirit and scope of the invention. In an

exemplary embodiment, the articulated arm **40** includes three members **42**, each being at least fifteen feet in length. Those skilled in the art will appreciate that a virtually infinite combination of numbers and lengths of members **42** is possible in configuring the articulated arm **40**.

Turning now to Figs. 2 and 3, there are shown two exemplary embodiments of the brush head assembly **60** employed in the ship hull cleaning apparatus **10** of the present invention. Generally, the brush head assembly **60** includes a yoke **62** pivotably mounted on the free end **46** of the articulated arm **40**, at least one brush drum **64** rotatably mounted within the yoke **64**, and a mechanical drive **66** (Fig. 4) installed on the yoke **64** in engaging relationship with the drum **64** so as to rotationally drive the drum **64** during cleaning. It will be appreciated that each drum **64** may be formed in a variety of shapes and from a number of materials known in the art to effectively remove any foreign objects from the ship hull **102** such as sea grasses, tubeworms, barnacles or the like. As such, it is to be understood that the finned, substantially cylindrical brush drums **64** shown and described are merely exemplary of the drums that can be employed in the cleaning apparatus **10** of the present invention. To further improve performance of the brush drums **64**, the drums **64** are configured within the yoke **62** to be rotated by the mechanical drive **66** in a direction opposite the direction of travel of the entire brush head assembly **60** over the surface of the ship hull **102** (Fig. 1), or to counter-rotate, as explained more fully below. In the embodiment shown in Fig. 2, the yoke **62** is configured for mounting two brush drums **64** in a substantially parallel, spaced-apart arrangement. The yoke **62** includes a back plate **68** with parallel pairs of brackets **70** extending therefrom and between which the drums **64** are rotatably mounted. Functionally installed between the back plate **68** of the yoke **62** and the member **42** located at the free end **46** is a device such as a hydraulic cylinder **72** for dynamically pivoting the yoke **62** about the free end **46** of the articulated arm **40**. In this way, the cylinder **72** is operable to selectively pivot the yoke **62** such that the two brush drums **64** are substantially in contact with the ship hull **102** (Fig. 1) during cleaning. Where hydraulic cylinders are employed throughout the cleaning apparatus **10**, it will be appreciated that a common power source (not shown) such

as a gasoline or diesel engine may be employed to generate the required hydraulic pressure for the hydraulic control systems, as is known in the art. As with the hydraulic cylinders **48** employed in the exemplary embodiment of the articulated arm **40**, it will be further appreciated that a number of other dynamic pivoting mechanisms other than the hydraulic cylinder **72** shown and described, such as a hydraulic ram, a hydraulic motor, a pneumatic cylinder, a pneumatic ram, a pneumatic motor, or an electric motor, may be employed in selectively pivoting the yoke **62** to optimally position the brush drums **64** against the ship hull **102** (Fig. 1). In the alternative embodiment of the brush head assembly **60'** shown in Fig. 3, the yoke **62'** is configured with opposing foot plates **70'** that are substantially triangular in shape and between which are rotatably mounted three brush drums **64'** substantially at the respective corners of the foot plates **70'** and in a substantially parallel, spaced-apart arrangement. The yoke **62'** is mounted on the free end **46'** of the articulated arm **40'** so as to pivot substantially about the centers of the respective foot plates **70'**. Because the yoke **42'** is freely pivotable about the free end **46'** of the member **42'**, it will be appreciated by those skilled in the art that two of the three brush drums **64'** will be substantially in contact with the ship hull **102** (Fig. 1) when the brush head assembly **60'** is positioned against the hull during cleaning. It will be further appreciated that other combinations of yokes and brush drums may be provided in the cleaning apparatus **10** without departing from the spirit and scope of the invention. In an exemplary embodiment, each brush drum is approximately 2-1/2 to 3 feet in diameter and approximately 6 feet in length. Turning now to Fig. 4, there is shown an alternative embodiment brush head assembly **60"** again having a back plate **68"** with two pairs of laterally extending brackets **70"** between which are rotatably mounted two brush drums **64"**. A monitoring device **74** such as a sensor, a motion detector, or a camera is mounted on the brush head assembly **60"** so as to monitor the movement of the brush head assembly **60"** as it is positioned against and cleans the ship hull **102** (Fig. 1). It will be appreciated by those skilled in the art that the monitoring device **74** may be connected to a control device (not shown) such as a computer or processor to provide the control device with the real-time information needed to control the hydraulic cylinders **48**, **72** (Figs. 1 and 2), and thus the articulated arm **40"**, in

dynamically and automatedly positioning the brush head assembly **60"**. In the exemplary embodiment shown, the monitoring device **74** is mounted on an angled plate **76** extending from the top edge **78** of the back plate **68"** so as to be generally aimed toward the area directly in front of the brush drums **64"**, though it will be appreciated that the monitoring device **74** may be mounted in numerous other locations on or about the brush head assembly **60"** or articulated arm **40"**. Referring still to Fig. 4, there is also shown a pressure nozzle **80** mounted on the brush head assembly **60"** and positioned so as to selectively direct a pressure spray toward the ship hull **102** (Fig. 1) substantially adjacent to the brush head assembly **60"**. As explained more fully below, the pressure spray serves to clean the debris loosened by the brush drums **64"** from the area of the ship hull **102** being cleaned. This action of the pressure nozzle **80** would not only then complete the cleaning process in cooperation with the brush drums **64"**, but would also clear away the cleaned area for more accurate monitoring of the brush head assembly **60"** by the monitoring device **74**. As shown in the exemplary embodiment, the pressure nozzle **80** may be mounted on a plate **82** extending from a side edge **84** of the back plate **68"**, though it will be appreciated by those skilled in the art that the pressure nozzle **80**, like the monitoring device **74**, may be mounted in numerous other locations on or about the brush head assembly **60"** or articulated arm **40"** so as to be directed toward the area of the ship hull **102** (Fig. 1) being cleaned. A wire **88** running from the monitoring device **74** and a line **86** carrying water or other cleaning fluid from a source (not shown) on the cleaning apparatus **10** or carrier **90** to the pressure nozzle **80** may be staked to and run along the articulated arm **40"** so as to be secured out of the way. It will be appreciated that the pressure for the fluid in the line **86** and sprayed from the nozzle **80** may be supplied by the same power source (not shown) used to supply the hydraulic pressure to the hydraulic systems of the cleaning apparatus **10**. The nozzle **80**, like the monitoring device **74**, may also be controlled by a computer or processor control device (not shown) so as to automate and control the entire operation of the cleaning apparatus **10** of the present invention without human involvement, making the apparatus efficient and safe.

In use, the cleaning apparatus **10** is first located adjacent to a ship **100** to be cleaned. When the apparatus **10** is installed on a carrier **90** such as a boat, the apparatus may be brought to the ship **100**, rather than bringing the ship **100** to the cleaning apparatus **10**, enabling the cleaning of a ship anchored at sea or in a harbor far from a dock or pier. This is particularly advantageous for cleaning large tankers and cargo ships that are not easily, and sometimes not possibly, brought in to port. Even when installed on a land mass, pier, dock, or land vehicle, the cleaning apparatus **10** of the present invention serves the beneficial purpose of cleaning a ship hull **102** without having to take the ship **100** out of the water, thereby avoiding the expense and inconvenience of dry docking the ship **100** to clean it. Once the cleaning apparatus **10** is located adjacent to the ship **100**, a stand-off arm **26** mounted on the apparatus **10** is extended laterally outwardly so as to contact the ship hull **102** above the water line and thereby safely space the apparatus **10** from the ship **100**. Because the ship **100** and the carrier **90**, even anchored, will be bobbing in the water and moving relative to one another during cleaning, the stand-off arm **26** is further provided with a roller **28** on its distal end so as to make rolling contact with the ship hull **102** and further protect it. Multiple stand-off arms **26** may also be provided to better keep the ship **100** and the carrier **90** spaced safely from each other along their respective entire lengths. With the apparatus **10** thus safely positioned adjacent to the ship **100**, the cleaning process can begin. The articulated arm **40** is maneuvered into the water between the carrier **90** and the ship **100** so as to generally orient the brush head assembly **60** toward the underwater portion of the ship hull **102**. In the preferred embodiment, the location of the brush head assembly **60** relative to the ship hull **102** is monitored in real time through a monitoring device **74** such as a sensor, motion detector, or camera. This real-time positioning data can be provided to a control device (not shown) such as a computer or processor, which control device may then in automated fashion control the movement of the articulated arm **40** by specifically controlling the hydraulic cylinders **48** installed along the arm about the hinge connections **44** between the arm's members **42**. In this way, a control loop is established between the monitoring device **74** and the control device so as to dynamically manipulate the articulated arm **40** through the hydraulic system. It will be appreciated that numerous types and

configurations of such control loop systems may be employed in the present invention for providing automation of the movement and positioning of the articulated arm **40**. Through such real-time, dynamic control and manipulation, the brush head assembly **60** is ultimately brought into contact with the underwater portion of the ship **102** as shown in Fig. 1. Such positioning may be further aided by rotation of the apparatus **10** relative to the carrier **90** about its rotatable base **22** mounted on the carrier **90** so as to cooperate with the articulated arm **40** in contacting the hull **102** with the brush head assembly **60**. Once the brush head assembly **60** is so positioned, the brush drums **64** are then rotated against the ship hull **102** to remove unwanted foreign objects that impair the movement and performance of the ship, such as sea grasses, tubeworms, barnacles, and the like. To enhance the cleaning performance of the brush drums **64**, the drums **64** are configured within the brush head assembly **60** to be rotated in a direction opposite the direction of travel of the brush head assembly **60** over the surface of the ship hull **102**. Like the positioning of the brush head assembly **60**, the cleaning of the ship hull **102** by the brush head assembly **102** is also monitored by the monitoring device **74**. The feedback from the monitoring device **74** to the computer or processor control device (not shown) enables the further automation of the cleaning process by allowing the control device to assess the cleaning progress and adjust the location of the brush head assembly **60** accordingly through the hydraulic system of the articulated arm **40**, as explained above. In addition to the positioning data provided by the monitoring device **74**, a device such as a sensor may perform the further feedback function of providing data regarding the pressure of the brush head assembly **60** against the ship hull **102** so as to effectively clean the hull with minimal damage. In the preferred embodiment, the computer or processor (not shown) is linked to and controls both the hydraulic system of the articulated arm **40** and the hydraulic drives **66** of the respective brush drums **64** so as to optimally control not only the brush head assembly **60** location, but the speed and direction of rotation of the individual brush drums **64** in conjunction with the movement of the brush head assembly **60** and the overall cleaning progress being made. To further improve the cleaning and monitoring processes, the ship hull cleaning apparatus **10** of the present invention is configured with a pressure nozzle **80** mounted on or about the brush head

assembly **60"** so as to selectively spray the area of the ship hull **102** adjacent to the brush head assembly **60"** with a pressurized spray of water or other cleaning fluid. This pressure spray cleans the debris loosened by the brush drums **64"** from the area of the ship hull **102** being cleaned so as to both improve the cleaning process in cooperation with the brush drums **64"**, but also clear away the cleaned area for more accurate monitoring of the brush head assembly **60"** by the monitoring device **74**. For optimal performance of the cleaning apparatus **10**, the pressure nozzle **80** is also controlled by the computer or processor (not shown) so as to coordinate all phases of the cleaning operation based on the real-time data received from the monitoring device **74**. As such, the power source (not shown) that may be installed on the apparatus **10** or carrier **90** so as to provide pressure to both the hydraulic systems, including the hydraulic cylinders **48**, **72**, and the pressure nozzle **80** is also optimally controlled by the control device in conjunction with the other elements of the overall cleaning apparatus **10**. It will be appreciated that during such use of the cleaning apparatus **10** the weight and movement of the articulated arm **40** will cause an uneven weight distribution about the carrier **90**, which imbalance may be further effectuated by the pressure exerted by the articulated arm **40** through the brush head assembly **60** against the ship hull **102**. To counterbalance this effect and prevent a carrier **90** such as a boat or land vehicle from capsizing or any other non-moving carrier from being subjected to extreme torsional or bending forces during operation of the articulated arm **40**, the counterweight **24** installed on the support frame **20** of the cleaning apparatus **10** substantially opposite of the articulated arm **40** is shifted along the frame **20** so as to counterbalance or offset the articulated arm **40** during use. The movement of the counterweight **24** in offsetting the movement of the articulated arm **40** is optimally and dynamically achieved by also being under the control of the computer or processor control device (not shown). It will thus be appreciated by those skilled in the art that the cleaning apparatus **10** of the present invention provides a safe and efficient system involving no divers or other human involvement in the function of cleaning an underwater ship hull **102**. This automated process, including real-time monitoring of the cleaning progress and adjustment of the cleaning head **60** against the ship hull **102** accordingly, results in a complete swath being cleaned. Moreover, it will be

appreciated that the great degree of flexibility and reach of the articulated arm **40** allows the apparatus **10** to clean ship hulls of virtually any size and shape automatically, without any manual adjustments or other retooling or retrofitting of the cleaning apparatus **10**.

While the invention has been described with reference to at least one preferred embodiment, it is to be clearly understood by those skilled in the art that the invention is not limited thereto. Rather, the scope of the invention is to be interpreted only in conjunction with the appended claims and it is made clear, here, that the inventor(s) believe that the claimed subject matter is the invention.